Non-Conventional Solutions to the Problem Treatment of Industrial Waste Water

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Abstract: This article discusses the problems of industrial wastewater treatment, and also provides the results of a theoretical study, thermodynamic substantiation and practical prospects for the use of nitrogen oxides (NO2, NO) instead of SO2 in the regeneration of cyanide solutions of the production of noble metals.

Keywords: Water, Treatment, Industrial.

The urgency of the problem. The problem of industrial wastewater treatment and water treatment for technical and household-drinking purposes is becoming more and more important every year. The complexity of cleaning is due to the extreme variety of impurities in the effluents, the amount and composition of which is constantly changing as a result of the emergence of new industries and changes in the technology of existing ones.

Today, all over the world, there are many industrial enterprises whose treatment facilities are ineffective, decommissioned, or nonexistent [1-4]. Today, all over the world, there are many industrial enterprises whose treatment facilities are ineffective, decommissioned, or nonexistent [1-4]. This leads to the fact that wastewater without the necessary preliminary treatment enters the city treatment facilities, causing significant harm to them, resulting in large fines imposed on enterprises for exceeding the standards for the discharge of pollutants. The situation when wastewater is discharged into a water body without any treatment at all is completely unacceptable. Therefore, practically at every industrial enterprise there is a need to build their own local treatment facilities.

When developing a project for the construction of treatment facilities, it is advisable to use wastewater treatment methods that would remove all pollution from them. The first question that arises before the owner of the enterprise is what capital and operating costs are required to implement the project and what is the economic feasibility of such investments?

At the same time, a significant reduction in operating costs with an insignificant effect on the final cleaning result is an important task for both the environmental authorities and the owners of the enterprise. This is due to the fact that with an increase in the use of reagents and energy carriers, not only direct costs increase, but also the degree of secondary environmental pollution. Therefore, the implementation of the treatment plant project requires a balance between minimizing the use of resources and the effectiveness of the proposed treatment processes, which becomes possible due to the introduction of modern scientific and technical achievements and developments.

Nowadays, there are many factors that affect the composition of effluents. Market relations require a wide and original range of products from each manufacturer. Therefore, the composition of wastewater is primarily influenced by production technologies and raw materials used in them. As secondary factors, the quality of raw water, climatic conditions, disposal of by-
products, etc. can have an impact. [5].

That is why it is impossible to use outdated sources of information and reference books, or general solutions and developments for the implementation of effective wastewater treatment technology and the construction of local treatment facilities at industrial enterprises. In order for the proposed solution to be truly effective, it is necessary to conduct a thorough initial survey, which can be conditionally divided into three main stages: collection of initial data, field work and calculations.

This paper presents the results of a theoretical study, thermodynamic substantiation and practical prospects for the use of nitrogen oxides (NO2, NO) in place of SO2 in the regeneration of cyanide solutions of the production of noble metals. It is known that in the process of leaching precious metals from beneficiated ore, the cyanidation method is used; in the final stage, after the extraction of the base metal by cementation with zinc dust, a significant amount of free cyanide and cyanide complexes of zinc and other accompanying metals in the processed ore remain in the resulting waste solution. This stage of production is characterized by a high specific consumption of the cyanide reagent and to prevent this, the waste cyanide solution is regenerated under the action of sulfur dioxide. The essence of the process lies in the fact that SO2 dissolving in the waste solution turns into an acid of medium strength - H2SO3 (K1 = 1.7 10-2, K2 = 6.8 10-8), which is 1.3 107 times stronger and is able to displace from solution a weaker acid - HCN (K = 1.32 10-9). The displaced HCN (gas) is absorbed into the alkali solution and subsequently reused in the cyanidation process [6].

Comparison of the dissociation constant of sulfurous and hydrocyanic acids with Kdiss = 4.6 10-4 nitrous acid, which is formed during the absorption of nitrogen oxides (NO2, NO), shows that although HNO2 is 37 times weaker than H2SO3, it is 3.5 105 times stronger HCN. This means that, theoretically, the products of absorption of nitrogen oxides are able to displace HCN from aqueous solutions and suggests the possibility of using industrially exhaust nitrous gases (xNO2 + yNO, x: y ≥ 0.6: 0.4) instead of SO2 in the regeneration of cyanide solutions.

To test this assumption, in accordance with the technology of regeneration of cyanide waste solutions [6], we studied the following possible reactions in 1-5 stages between the components of cyanide solutions and nitrous gases:

1. Neutralization of protective alkali:
   \[ \text{Ca}^2+ + 2 \text{OH}^- + 2\text{NO}_2 + 0.5\text{O}_2 = \text{Ca}^2+ + 2\text{NO}_3^- + \text{H}_2\text{O} \]
   \[ \text{Ca}^2+ + 2 \text{OH}^- + 2\text{NO} + 0.5\text{O}_2 = \text{Ca}^2+ + 2\text{NO}_2^- + \text{H}_2\text{O} \]

2. Displacement of free hydrogen cyanide:
   \[ 2\text{CN}^- + 2\text{NO}_2 + 0.5\text{O}_2 + \text{H}_2\text{O} = 2\text{NO}_3^- + 2\text{HCN} \]
   \[ 2\text{CN}^- + 2\text{NO} + 0.5\text{O}_2 + \text{H}_2\text{O} = 2\text{NO}_2^- + 2\text{HCN} \]

3. Decomposition of cyanide complexes of metal ions:
   \[ \text{[Zn (CN) 4]}^2- + 4\text{NO}_2 + \text{O}_2 + 2\text{H}_2\text{O} = \text{Zn}^2+ + 4\text{NO}_3^- + 4\text{HCN} \]
   \[ \text{[Zn (CN) 4]}^2- + 2\text{NO} + 0.5\text{O}_2 + \text{H}_2\text{O} = \text{Zn}^2+ + 2\text{NO}_2^- + 2\text{HCN} + 2\text{CN}^- \]
   \[ \text{[Cu (CN) 3]}^2- + 2\text{NO}_2 + 0.5\text{O}_2 + \text{H}_2\text{O} = \text{CuCN} + 2\text{NO}_3^- + 2\text{HCN} \]
   \[ \text{[Cu (CN) 3]}^2- + 2\text{NO} + 0.5\text{O}_2 + \text{H}_2\text{O} = \text{CuCN} + 2\text{NO}_2^- + 2\text{HCN} \]

4. Decomposition of mixed (cyanide) complexes of metal ions:
   \[ \text{[Ag (CNS) (CN) 2]}^2- + 2\text{NO}_2 + 0.5\text{O}_2 + \text{H}_2\text{O} = \text{AgCNS} + 2\text{NO}_3^- + 2\text{HCN} \]
   \[ \text{[Ag (CNS) (CN) 2]}^2- + 2\text{NO} + 0.5\text{O}_2 + \text{H}_2\text{O} = \text{AgCNS} + 2\text{NO}_2^- + 2\text{HCN} \]
5. Absorption of released hydrogen cyanide by alkali solution:

\[
\text{[Cu (CNS) (CN) 3]}^{-3} + 4\text{NO}_2 + \text{O}_2 + 2\text{H}_2\text{O} = \text{CuCNS} + 4\text{NO}_3^- + \text{H}^+ + 3\text{HCN}
\]

\[
\text{[Cu (CNS) (CN) 3]}^{-3} + 4\text{NO} + \text{O}_2 + 2\text{H}_2\text{O} = \text{CuCNS} + 4\text{NO}_2^- + \text{H}^+ + 3\text{HCN}
\]

5. Absorption of released hydrogen cyanide by alkali solution:

\[n\text{HCN (gas)} + \text{Mn} + (\text{solution}) + n\text{OH}^- (\text{solution}) = n\text{CN}^- (\text{solution}) + \text{H}_2\text{O} + \text{Mn} + (\text{solution})\]

\[\text{E}_0\text{NO}_2 + 2\text{H}_2\text{O} - 2e = 2\text{NO}_3^- + 4\text{H}^+ + + 0.755 \text{ ~V}\]

\[\text{E}_0\text{NO} + \text{H}_2\text{O} - e^- =\text{NO}_2^- + 2\text{H}^+ + 1.00 \text{ ~V}\]

\[\text{Cyanide compounds of the waste solution do not participate in OM reactions, therefore their ORP is taken into account here.}\]

The calculations used the fundamental relations of the thermodynamics of organic matter processes:

\[\Delta E_{ovr} =\text{Eo oxidant} - \text{Eo-reducing agent};\]

\[\Delta G_{298} = -\Delta E_{ovr} \cdot n \cdot F;\]

\[\lg K_{rev} = (\Delta E_{ovr} \cdot n \cdot F) / 2,3RT\]

Based on the calculation results, the following values were obtained:

for the case of NO\textsubscript{2} absorption:

\[\Delta E_{ovr} = +0.473 \text{ ~V} > 0;\]

\[\Delta G_{298} = -45.644 \text{ KJ} < 0 \text{ and } K_{rev} = 1 \cdot 108\]

for the case of NO absorption:

\[\Delta E_{ovr} = +0.228 \text{ ~V} > 0;\]

\[\Delta G_{298} = -22.0 \text{ KJ} < 0 \text{ and } K_{rev} = 1 \cdot 103\]

Judging by the data obtained, it can be concluded that under the action of the components of exhaust nitrous gases, it is thermodynamically and kinetically possible to regenerate cyanide solutions of hydrometallurgical production of precious metals, which indicates the practical prospects of the proposed method. The depth and rate of the process depend on the quantitative ratio x\textsubscript{NO2} / y\textsubscript{NO}, i.e. the largest amount of nitrogen dioxide in the mixture contributes to the process with increased productivity. The stated results are the theoretical basis for the regeneration of cyanide solutions.

**Literature:**


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